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(54) IMPROVEMENTS IN OR RELATING TO MICROCIRCUIT PACKAGES

(71) We, UNITED KINGDOM ATOMIC ENERGY AUTHORITY, London, a British Authority do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to microcircuit packages and methods for the sealing thereof.

U.K. Patent No. 1,431,919 discloses a method for sealing a microcircuit package and forming the microcircuit therein in which a fused solderable metal or alloy track is formed over a fused vitreous track adhering to the package substrate, the metal or alloy track and the vitreous track substantially corresponding in shape and size to the sealing rim of the enclosing lid, the sealing rim being soldered to the metal or alloy track. The metal or alloy track may be an alloy of platinum and gold, palladium and gold, palladium and silver or gold alone.

According to the present invention in a process for the fabrication of a microcircuit package having an insulating substrate and a lid sealed to the substrate and enclosing the microcircuit, a method for sealing the package includes forming a fused vitreous track on the substrate in the form of a closed loop, forming a metallic track overlying the vitreous track by deposition thereover and fusion of a metallising paste, the said tracks corresponding in shape and size to the sealing rim of the lid, overcoating the metallic track with a coating of solderable metal or alloy and solder-bonding the sealing rim of the lid to the coated metallic track.

Advantageously the line circuitry of the microcircuit is formed on the substrate prior to the formation of the fused vitreous track and any circuit components required to form the microcircuit inserted into the pre-formed line circuitry immediately prior to solder-bonding the sealing rim of the lid to the coated metallic track.

The term "line circuitry" means the interconnecting conductor array and any printed resistor array of a microcircuit. The term "circuit component" means non-printed components such as power-dissipating chips and chip capacitors which are inserted into printed circuitry at locations depending upon the circuit design.

It is known that circuit components such as the so-called semi-conductor "chips" incorporated in most microcircuits cannot withstand the temperatures that are needed in forming the fused vitreous track and metallic track. Such components need to be inserted into the microcircuit after the fused vitreous track and metallic track have been formed but prior to solder-bonding.

The metallising paste used to form the metallic track may be a metallising paste as described in any one of claims 1 to 12 of UK Patent No. 1,378,520 which claims metallising pastes comprising a heat-vapourisable liquid medium containing as powder a glaze material and a component selected from aluminium or any alloy thereof, wherein the glaze dissolves the oxide of the metal or alloy and wets ceramic surfaces at the fusion temperature of the glaze. The metallising paste described may comprise aluminium powder and a glaze

comprising oxides of boron and lead. Preferably the paste comprises, in addition, a thermally decomposable compound of nickel according to the composition disclosed in UK Patent No. 1,412,341. As stated therein suitable thermally decomposable compounds of nickel include nickel organometallic compounds such as nickel resinate and are preferably present in the proportion 5—15 parts by weight per 100 parts of glaze material and component selected from aluminium or an alloy thereof.

With the metallising pastes mentioned above the preferred solderable metal or alloy is a metal or alloy selected from silver, nickel or solderable alloys thereof including silver-palladium alloys containing up to 90 per cent by weight of palladium.

Conveniently the metallic track is overcoated by printing a silver-containing paste thereon and drying and firing the paste to form a fused silver-based overcoat. The silver-containing paste may comprise silver or palladium/silver powder admixed with a powdered vitreous phase and a liquid vehicle. Alternatively, the metallic track may be overcoated by electroless plating of nickel thereon.

Typically the metallic track may be 0.001 in. to 0.0015 in. thick whereas the overcoat is a thin coating having a preferred thickness of 0.0005 in. when plated and 0.0005 in. to 0.0008 in. thick when printed.

Alternatively the metallising paste used to form the metallic track may be a metallising paste as claimed in claim 1 or claim 2 of UK Patent No. 1,356,577 which claims a metallising paste comprising a heat-vapourisable inert liquid medium and a metal frit mixture wherein the mixture consists of at least one constituent in powder form selected from the group consisting of a noble metal, and oxide of a noble metal and an oxide of a noble metal alloy, at least one constituent in powder form selected from the group consisting of copper and copper oxide in amounts ranging from 1 to 50% by weight, and a vitreous frit powder, said frit having a fusion temperature less than the melting temperature of the noble metal-copper-oxide alloy formed on fusing the powder constituents of the paste and being present in amounts less than 10% by weight, the stated percentages being weight percentages of the mixture, the noble metal-containing constituent constituting the balance of the mixture. The metallising paste may comprise, as the noble metal constituent, one or more of the following: silver, gold, silver-gold alloy, silver oxide. Silver and/or silver oxide is preferred.

With these metallising pastes the preferred solderable metal or alloy is silver or a silver-palladium alloy. Here also the metallic track is conveniently overcoated by printing a silver-containing paste thereon and drying and firing the paste to form a fused silver-based overcoat. Again the silver-containing paste may comprise silver or palladium/silver powder admixed with a liquid vehicle and optionally small amounts of a vitreous phase.

Typically the metallic track is again 0.001 in.—0.0015 in. thick whereas the overcoat is a thin coating having a preferred thickness of 0.0005 in.—0.0008 in.

The fused vitreous track may be formed by screen-printing a vitreous-containing paste onto the substrate to form a printed track and, thereafter, drying and firing the printed track. The metallic track may then be formed by screen-printing the noble metal containing metallising paste onto the fused vitreous track to form an overlaying paste track and, thereafter, drying and firing the overlaying paste track.

Alternatively the fused vitreous track and the fused metallic track may be formed by screen-printing a vitreous-containing paste onto the substrate to form a printed track, drying the printed vitreous track, screen-printing the metallising paste onto the dried vitreous track to form an overlaying paste track, drying the overlaying metallic paste track and, thereafter, firing the dried vitreous track and the dried metallic paste track together in one firing treatment.

Microcircuit packages wherein the package is sealed according to the present invention may have the connector pads joined to the circuitry and extending outwardly therefrom in a direction substantially at right angles to the plane of the circuitry through sealed orifices in the substrate for lead attachment at the underside thereof. Alternatively the pads may extend laterally in the plane of the circuitry: in this arrangement the vitreous-containing paste is screen-printed to form a printed track bridging over the connector pads and having a substantially flat upper surface.

The vitreous-containing paste may consist of an organic carrier liquid mixed with a powdered glaze containing particles of a refractory oxide, said oxide being related to said glaze such that on heating the glaze at a temperature above its minimum working temperature the working temperature of the glaze is progressively raised towards that higher temperature by solution of some of the particulate refractory oxide in the glaze. Such a paste is disclosed in UK Patent No. 1,254, 101.

Glazes formed from the vitreous-containing pastes of UK Patent No. 1,254,101 are sometimes referred to as "zero-flow glazes". One suitable range of glaze materials consists of a powdered glaze and 10 to 40 wt % of alumina of a particle size in the range of 2 to 30 microns.

Alternatively the vitreous-containing paste may consist of an organic carrier liquid mixed with a powdered recrystallizing glass. A recrystallizing glass is known to be a glass having an amorphous structure at room temperatures, which structure transforms to a partially crys-

talline solid at elevated temperatures, the transformation being reversible. The incidence of crystallinity with rising temperature restricts the mobility of the glass which tends not to flow. One suitable range of recrystallizing glasses is based on lead borosilicate having additions made thereto of between 1.0 wt % and 20.0 wt % of titania, lithia, Zn oxide, Cu oxide or Cu iodide.

It is preferred to solder-bond the sealing rim of the lid to the coated metallic track by screen-printing a paste comprising particulate solder onto the coated track to form a continuous track of particulate solder thereover, drying and firing the continuous track to fuse the solder, positioning a solder pre-form of substantially corresponding size and shape on the fused track, solder-coating the sealing-rim of the enclosing lid, positioning the coated rim on the solder pre-form, heating the assembled package so that the solder can flow and effect a sealed joint, and allowing the sealed joint to cool. In the context of the present invention a solder pre-form is an annular element having flat surfaces fabricated from a solder.

The invention also provides microcircuit packages fabricated as aforesaid.

The nature of the present invention is hereinafter further explained, by way of example, with reference to the drawing accompanying Provisional Specification No. 32202/74 which illustrates a section through the solder-bonded seal arrangement of part of a package.

In the drawing an alumina substrate 1 (100 mm × 50 mm × 1 mm) having circuitry (not shown) formed thereon and connector pads 4 extending laterally therefrom has a lid 2 positioned over the circuitry, which lid is solder-bonded in position. In forming the seal a vitreous-containing paste was screen-printed onto the substrate to form a printed track surrounding the circuitry and bridging over the connector pads 4: the printed track had a substantially flat upper surface and was dried and fired to form the fused vitreous track 5 corresponding in shape and size to the sealing-rim 3 of lid 2. An aluminium-containing metallising paste was then screen-printed onto the track 5 to for man overlaying paste track, which track was dried and fired to form overlay 6. The metallic overlay track 6 was overcoated by electroless plating with nickel using the following solution.

Sodium hypophosphite (NaH_2PO_3) 23 gm/litre

Nickel sulphate ($NiSO_4 7H_2O$) 25—30 gm/litre

Sodium Acetate ($NaC_2H_3O_2$) 8 gm/litre

Sodium citrate ($Na_3C_6H_3O_7 2H_2O$) 8 gm/litre

Sodium tartrate ($Na_2C_4H_4O_6 . 2H_2O$) 1 gm/litre

Molybdic acid ($MoO_3 . H_2O$) 0.38 mg/litre

Solution temperature 75—80° C

pH 7.0—8.0

and a coating 9 of 0.0005 in. thickness was formed by immersing the printed substrate therein for 30—40 minutes.

The metallic overlay 6 may also be formed by screen-printing a noble metal paste onto the track 5 to form an overlying paste track, the track being dried and fired. In this case the overlay track was overcoated by screen-printing a silver-containing paste thereon: the paste was a mixture of silver metal and a polymerised cyclic ketone dissolved in terpineol as carrier and a coating 9 of 0.0005 in. thickness was formed after firing at 930° C. In solder-bonding the sealing rim 3 of the lid to the overcoated track a paste comprising particulate solder was screen-printed onto the coating 9 to form a continuous track of particulate solder thereover, the printed track was dried and fired to fuse the solder and form a fused solder track 7, a solder pre-form 8 of corresponding size and shape was positioned on the fused track of particulate solder, the sealing-rim 3 of the lid was solder-coated, the lid was positioned with the rim 3 in contact with the pre-form 8 and thus-assembled package was heated to allow the solder to flow and effect a sealed joint after which the package was cooled. In the fabrication of a hermetically-sealed microcircuit package from the formed and enclosed microcircuit thus produced, suction can be applied to an orifice (not shown) in lid 2 to evacuate air from the package and the orifice sealed off as is known in the art. Alternatively, prior to sealing-off the evacuated package, an inert gas (eg argon) can be admitted to the package through the orifice.

Suitable vitreous-containing pastes are disclosed in UK Patent No. 1,254,101. The vitreous pastes can be prepared by mixing a powdered glaze containing particles of refractory oxide with pine oil screening medium.

The screening medium is present in amounts such as to yield a paste having a consistency suitable for screen printing. Suitable combinations of glaze and refractory oxides are as follows, the firing temperatures for the combinations also being quoted:—

Refractory Oxide			Glaze	Firing Temp of Paste (°C)
Type	Proportion	Particle Size (microns)		
Alumina	20%	2	Na Borosilicate	850
Alumina	30%	20	Pb Borosilicate	900
Alumina	30%	20	Na Borosilicate + titania	800–850 (for 30 minutes)
Alumina	10%	20	$2CaO \cdot 9B_2O_3 - Al_2O_3$	1000
Titania	25%	10	Na Borosilicate	850
Titania	25%	10	Pb Borosilicate	820
Titania	25%	10	Na Borosilicate + titania	880
Alumina	10%	20	$PbO \cdot ZrO_2 - SiO_2$	800

Prior to firing at the stated temperatures the pastes are dried-out by heating at about 150° C. The dried pastes are heated to firing temperature in about 15 mins, held at temperature for 15 mins (or as specified) and cooled in 15 mins. The proportion of refractory oxide particles is specified at a % by weight of the oxide-plus-glaze mixture.

The lid can be fabricated from an Fe-Ni-Co alloy or from Mo metal. A preferred alloy is 54% Fe, 29% Ni, 17% Co (by weight). Sheet material of 0.010 in. thickness is, for example, suitable. The lid material should ideally have the same thermal expansion characteristic as the substrate. In practice suitable materials are those metals and alloys having small expansion coefficients in common with the small coefficient for alumina.

The aluminium metallising paste can be a paste comprising aluminium powder and boric oxide and lead oxide powders, a typical paste consisting of 100 gm of solids (92 gm Al, 6 gm PbO, 2 gm B_2O_3) and 35 cc of liquid carrier, a suitable carrier being a polymerised cyclic ketone dissolved in terpineol. The paste can with benefit contain a nickel resinate added in liquid form (dissolved in an organic solvent). A suitable resinate-containing paste consists of 20 cc of liquid carrier for every 65 gm of solids, consisting of 50 gm Al powder and 10 gm lead borosilicate glaze powder together with 5 gm of liquid resinate. The screen-printed pastes are dried (at about 120° C) and fixed at 830—950° C.

Noble-metal-containing metallising paste can be paste comprising silver oxide and copper oxide powders and vitreous frit powder, a typical paste consisting of 100 gm of solids (85 gm Ag_2O, 10 gm Cu_2O and 5gm frit powder) and 35 cc of liquid carrier, a suitable carrier being a polymerized cyclic ketone dissolved in terpineol. The screen-printed metallising paste is dried (at about 120° C) and fired at 1000° C.

Suitable pastes comprising particulate solder can be made from the following solder alloys. The melting temperatures are also shown:—

Alloy								Melting Temperature (°C)
Sn	Pb	Bi	In	Cd	Ag	Au	Sb	
65	35	–	–	–	–	–	–	183
62	36	–	–	–	2	–	–	180
10	90	–	–	–	–	–	–	280
5	90	–	–	–	5	–	–	318
20	–	–	–	–	–	80	–	(eutectic) 280
95	–	–	–	–	–	–	5	(eutectic) 240
95	–	–	–	–	5	–	–	(eutectic) 221
–	–	–	90	–	10	–	–	145
–	–	–	97	–	3	–	–	(eutectic) 141
90	–	–	–	–	–	10	–	(eutectic) 217
8	23	45	19	5	–	–	–	(eutectic) 47
12	18	49	21	–	–	–	–	58
16	–	33	51	–	–	–	–	61
–	–	30	62	8	–	–	–	62
–	26	52	22	–	–	–	–	70
13	37	50	–	10	–	–	–	70
–	–	34	66	–	–	–	–	72
17	–	57	26	–	–	–	–	79
–	4	52	–	8	–	–	–	93
42	–	–	44	14	–	–	–	93
16	32	52	–	–	–	–	–	96
26	–	54	–	20	–	–	–	103
–	–	68	32	–	–	–	–	109
48	–	52	–	–	–	–	–	117
–	–	–	75	25	–	–	–	123
–	45	55	–	–	–	–	–	124
15	10	–	70	5	–	–	–	125
42	–	58	–	–	–	–	–	138
37.5	37.5	–	25	–	–	–	–	140
–	–	60	–	40	–	–	–	144
51	31	–	–	18	–	–	–	145
–	15	–	80	–	5	–	–	149
68	–	–	–	32	–	–	–	177

The solder for the pre-form can be selected from the same range of alloys: the solder in the paste and for the pre-form can be, but are not necessarily, the same alloy. The particulate solder pastes usually contain an activated resin as a solvent soluble flux.

The assembled package is heated to the appropriate working temperature for the selected solder so that the solder can flow and effect a sealed joint. When sealing in air an improved solder joint is obtained if a water-white-rosin flux (rosin dissolved in isopropyl alcohol) is applied.

The sealing rim of the lid can be solder-coated by applying solder alloy thereto. The solder for the coating and of the pre-form should preferably be the same alloy (but they need not necessarily be so). It is preferred to copper- or nickel-plate the lid before solder-coating to improve bonding.

It has been found that whereas packages used in the art have been limited generally to 1.5 in. square size with the occasional use of rectangular packages of 2 in. × 1 in., packages produced according to the present invention can, typically, be 4 in. × 2 in. in size.

WHAT WE CLAIM IS:—

1. In a process for the fabrication of a microcircuit package having an insulating substrate and a lid sealed to the substrate and enclosing the microcircuit, a method for sealing the package including forming a fused vitreous track on the substrate in the form of a closed loop, forming a metallic track overlying the vitreous track by deposition thereover and fusion of a metallising paste, the said tracks corresponding in shape and size to the sealing rim of the lid, overcoating the metallic track with a coating of solderable metal or alloy and solder-bonding the sealing rim of the lid to the coated metallic track.

2. A method as claimed in claim 1 in which the line circuitry of the microcircuit is formed on the substrate prior to the formation of the fused vitreous track and any circuit components required to form the microcircuit are inserted into the pre-formed line circuitry immediately prior to solder-bonding the sealing rim of the lid to the coated metallic track.

3. A method as claimed in claim 2 in which the metallising paste is a metallising paste as claimed in any one of claims 1 to 12 of UK Patent No. 1,378,520.

4. A method as claimed in claim 3 wherein the solderable metal or alloy is a metal or alloy selected from silver, nickel or solderable alloys thereof including silver-palladium alloys containing up to 90 per cent by weight of palladium.

5. A method as claimed in claim 3 in which the metallising paste also contains between 5 and 15 parts by weight of a thermally decomposable compound of nickel per 100 parts of glaze material and component selected from aluminium or alloy thereof.

6. A method as claimed in claim 5 in which the thermally decomposable compound of nickel is nickel resinate.

7. A method as claimed in any preceding claim in which the solderable metal is nickel and the metallic track is overcoated by electroless plating.

8. A method is claimed in any one of claims 1 to 6 in which the coating of solderable metal is formed by printing a silver-containing paste over the metallic track and firing the paste to form a fused silver-based overcoat.

9. A method as claimed in claim 8 in which the silver-containing paste consists of silver or palladium/silver powder admixed with a vitreous phase and a liquid vehicle.

10. A method as claimed in any one of claims 3, 4, 5, 7, 8 or 9 in which the metallic track is between 0.001 in. and 0.0015 in. thick and the coating of solderable metal is between 0.0005 in. and 0.0008 in. thick.

11. A method is claimed in claim 7 in which the metallic track is between 0.001 in. and 0.0015 in. thick and the coating of electroless nickel is approximately 0.0005 in. thick.

12. A method as claimed in any one of the preceding claims in which the sealing rim of the lid is solder-bonded to the metallic track by screen-printing a paste comprising a particulate solder onto the coated metallic track to form a continuous track of solder thereover, drying and firing the continuous track to fuse the solder, positioning a solder pre-form of substantially corresponding size and shape on the fused solder track, solder-coating the sealing rim of the lid, positioning the coated sealing rim on the solder pre-form, heating the assembled package so that the solder can flow and effect a sealed joint, and allowing the sealed joint to cool.

13. A method as claimed in claim 2 in which the metallising paste is a metallising paste as claimed in claim 1 or claim 2 of UK Patent No. 1,356,577.

14. A method as claimed in claim 13 wherein the solderable metal or alloy is selected from silver or a palladium-silver alloy.

15. A method as claimed in claim 14 in which the coating of solderable metal is formed by printing a silver-containing paste over the metallic track and firing the paste to form a fused silver-based overcoat.

16. A method as claimed in claim 12 in which the silver-containing paste comprises silver or palladium/silver powder admixed with a vitreous phase and a liquid vehicle.

17. A method as claimed in any one of claims 13 to 16 in which the metallic track is between 0.001 in. and 0.0015 in. thick and the coating of solderable metal is between 0.0005 in. and 0.0008 in. thick.

18. A method as claimed in any one of claims 13 to 17 in which the sealing rim of the lid is solder-bonded to the metallic track

by screen-printing a paste comprising a particulate solder onto the coated metallic track to form a continuous track of solder, thereover, drying and firing the continuous track to fuse the solder, positioning a solder pre-form of substantially corresponding size and shape on the fused solder track, solder-coating the sealing rim of the lid, positioning the coated sealing rim on the solder pre-form, heating the assembled package so that the solder can flow and effect a sealed joint, and allowing the sealing joint to cool.

19. A method as claimed in claim 1 and substantially as hereinbefore described.

20. A method as claimed in claim 3 and substantially as hereinbefore described.

21. A method as claimed in claim 13 and substantially as hereinbefore described.

22. A microcircuit package produced by a method as claimed in claim 1, claim 2 or claim 19.

23. A microcircuit package produced by a method as claimed in any one of claims 3—12 and 20.

24. A microcircuit package produced by a method as claimed in any one of claims 13—18 and 21.

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1468973 PROVISIONAL SPECIFICATION
1 SHEET *This drawing is a reproduction of the Original on a reduced scale*